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(54) **WATER PURIFYING SYSTEM**

WASSERREINIGUNGSVORRICHTUNG

SYSTEME DE PURIFICATION D'EAU

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Description

[0001] The present invention relates to a system and a method of purifying water. More particularly, the invention relates to a system and a method of purifying water of pathogenic micro-organisms such as *Giardia* and *Cryptosporidium*.

[0002] Polluted drinking water is a great problem and causes mild affections as well as serious diseases and even deaths. In the US, a number of serious outbreaks have been registered as a consequence of drinking water being polluted. Especially harmful effects are caused by the water-borne parasites *Giardia* and *Cryptosporidium*. A crucial problem with these organisms is that they cannot be efficiently eliminated from water by applying known methods. The organisms can be found in the whole world, but are most common in warm countries and they cause diarrhoea, stomach pain and nausea. The most serious outbreak of cryptosporidiosis in the US occurred in 1993 in Milwaukee in which 400,000 people were taken ill with polluted drinking water.

[0003] Normally, drinking water is purified in several steps such as by flocculation, sedimentation, filtration through sand and chlorination. However, micro-organisms have an incredible ability to adjust to different environments and they gradually become resistant to common bactericidal systems and disinfectants. *Cryptosporidium* is, for instance, resistant to chlorine and can resist 3 % chlorine for 18 hours. However, the WHO recommend only 0.5 ppm chlorine in drinking water.

[0004] In US-A-5,935,431, an integrated filtration and sterilisation apparatus is described. In the apparatus, inlet water is first filtered through a filter bed of, for instance, active carbon, adsorption resin, zeolite, reduction catalysts, paper, polymers, clay, metals, etc. The filter material in this apparatus serves to separate particulate, organic or inorganic compounds from inlet water. If an inorganic material, such as heavy metals or sulphites, is to be removed, the filter material is preferably an ion-exchange resin, a zeolite or a reduction catalyst. The permeate, i.e. the filtered inlet water, is then exposed to UV radiation and ozone treatment, said ozone treatment giving rise to bacterial killing.

[0005] Besides being resistant to chlorine; *Cryptosporidium* is also very resistant to UV radiation and ozone. 1 ppm ozone for 5 minutes results in only 90 % killing. However, such high concentrations of ozone are not permitted; only 0.4 ppm is permitted in outlet water intended for drinking water.

[0006] US-A-5,935,431 does not mention how many ppm ozone are added to the outlet water, but this method suffers from the drawback that in ozone treatment degradation products form from the killed bacteria. It is not advisable to directly use the water discharged from this apparatus as drinking water, on the one hand, owing to the degradation products formed and, on the other, owing to possibly remaining ozone.

[0007] Both *Giardia* and *Cryptosporidium* have a

spore stage in their life cycles. The spores are much smaller than the actual organisms and the oocysts of *Cryptosporidium* can be as small as 4 μm . Today, only ultrafiltration or reverse osmosis can separate such small particles, but the methods are too expensive to be used for large volumes of water.

[0008] Thus there is a great need for a new system for purifying drinking water which is capable of dealing with *Cryptosporidium*, *Giardia* and other pathogenic, water-borne micro-organisms.

[0009] One object of the present invention is to provide a system and a method in which water containing *Cryptosporidium* and *Giardia* can be efficiently purified with excellent results.

[0010] Other objects, features and advantages of the present invention will be apparent from the description below.

[0011] These objects are achieved by a system and a method according to the independent claims. Particularly preferred embodiments are defined in the dependent claims.

[0012] In short, the present invention relates to a system for water purification comprising at least two units, of which the first unit comprises at least one filter unit which consists of a container containing a filter bed of zeolite, and of which the second unit consists of a container enclosing a UV lamp. The two units are connected to each other by means of a conduit for conveying water. According to the invention, the filter bed consists of at least 50 % by weight natural zeolite with a pore diameter of 0.05-5 nm. The pressure in the filter bed is 1-4 bar and the UV lamp has a light intensity of 300-500 J/m².

[0013] It has, surprisingly, been found that excellent results are achieved when water containing *Cryptosporidium* and *Giardia* is purified in accordance with the method and the purifying system according to the present invention. Preliminary results show that a substantially complete reduction of *Cryptosporidium* and *Giardia* is obtained.

[0014] Preferred embodiments of the present invention will be described below, partly with reference to the accompanying drawing. The drawing must not be considered to limit the scope of the present invention.

[0015] The Figure is a schematic view of the system according to a preferred embodiment of the present invention.

[0016] Water purifying systems according to the present invention comprises at least two units. The first unit comprises at least one filter unit 1, which consists of a container 2 containing a filter bed 3 of zeolite. The second unit 4, the UV unit, consists of a container 5 enclosing a UV lamp 6. At the filter unit 1, the system is provided with an inlet 9 and at the UV unit 4 with an outlet 10. The two units are connected to each other by means of conduits 7 for conveying water, and the water moves through the purifying system in the direction shown by the arrows P1.

[0017] The filter bed 3 consists of at least 50 % by

weight natural zeolite, which preferably is clinoptilolite and/or mordenite. The zeolite has a pore diameter of 0.05-5 nm, preferably 0.08-3 nm and most preferably 0.1-1 nm. The grain size of the zeolite is 0.1-2.5 mm, preferably 0.6-2.0 mm.

[0018] The filter bed 3 has an inner filter surface of 50-600 m²/g, preferably 200-500 m²/g, and during operation the pressure in the filter bed is 1-4 bar, preferably 1.5-3.5 bar and most preferably 2.5-3.4 bar. The pressure is important for the zeolite to be compacted in the filter bed 3 and providing the desired purifying capacity. The pressure in the filter bed should be so high that particles larger than 1 µm get caught and stay in the filter. The pressure can be regulated by means of a water pump (not shown) for inlet water. A throttle valve 11 after the filter unit 1 makes it possible to quickly raise the pressure in the filter unit.

[0019] Besides the natural zeolite, the filter bed 3 can also contain montmorillonite, quartz, feldspar and vulcanised rock crystal.

[0020] The zeolite in the filter bed must have a certain hardness to be able to resist the pressure in the filter bed and should be able to resist a pressure of at least 2.5 bar, preferably at least 4 bar, and also be able to resist pressure fluctuations of up to 6 bar.

[0021] If several filter units are used, they can be connected either in parallel or in series.

[0022] The UV radiation takes place at a wave length of 200-280 nm, preferably 254 nm with a lamp 6 with a UV-C filter. The light intensity should preferably be 300-500 J/m², more preferably 350-450 J/m² and most preferably 400-430 J/m². UV light with a normal light intensity of about 250 J/m² does not provide the desired killing effect on the micro-organisms.

[0023] To ensure that the particle size is less than 1 µm at all points of time in the purification process, also after back flushing for cleaning the filter unit, a bag filter 8 can be placed between the filter unit 1 and the UV unit 4. The bag filter 8 is preferably made of polypropylene having a mesh size of less than 1 µm. As an alternative to the bag filter 8, it is possible (in a manner which is not shown in the Figure), after back flushing for cleaning the filter unit 1, to let water discharged from the filter unit return to the inlet 9 in the filter unit 1 until a sufficiently high pressure has been built up in the filter bed 3.

[0024] The present invention also relates to a method of purifying water, in particular of *Cryptosporidium*, in which the water is exposed to the above-described purifying system, for producing drinking water.

[0025] Even if the advantages of the invention have been described with reference to drinking water, the purifying system can, of course, be used for purifying other types of water, of which swimming-pool water is of particular interest.

[0026] When affording aid to emergency areas and countries devastated by war, it is important to have reliable, rapid, simple and cheap systems at hand for purifying water. One embodiment of the invention relates

to a mobile purifying system for use in the field, which involves the above-described purifying system. In this case, the purifying system is mounted on a trailer and comprises a pump for pumping surface water, a sludge filter, filter units with a filter bed of zeolite, possibly a bag filter, a UV source, chlorinating equipment and a collection tank for the purified water.

10 Claims

1. A system for water purification comprising at least two units, of which the first unit comprises at least one filter unit (1) which consists of a container (2) containing a filter bed (3) of zeolite, and of which the second unit (4) consists of a container (5) enclosing a UV lamp (6), said two units being connected to each other by means of a conduit (7) for conveying water,
characterised in that the filter bed (3) consists of at least 50 % by weight natural zeolite with a pore diameter of 0.05-5 nm, that means are provided to regulate the pressure in the filter bed to be 1-4 bar, and that the UV lamp (6) has a light intensity of 300-500 J/m².
2. A system as claimed in claim 1, **characterised in that** the natural zeolite in the filter bed (3) preferably consists of clinoptilolite and/or mordenite.
3. A system as claimed in claim 1 or 2, **characterised in that** the filter bed (3) has an inner filter surface of 50-600 m²/g.
4. A system as claimed in any one of the preceding claims, **characterised in that** the filter bed (3) has an inner filter surface of 200-500 m²/g.
5. A system as claimed in any one of the preceding claims, **characterised in that** the zeolite has a pore diameter of 0.08-3 nm.
6. A system as claimed in any one of the preceding claims, **characterised in that** the zeolite has a pore diameter of 0.1-1 nm.
7. A system as claimed in any one of the preceding claims, **characterised in that** the light intensity of the UV lamp (6) is 350-450 J/m².
8. A system as claimed in any one of the preceding claims, **characterised in that** the light intensity of the UV lamp (6) is 400-430 J/m².
9. A system as claimed in any one of the preceding claims, **characterised in that** the pressure in the filter unit (1) is 1.5-3.5 bar.

10. A system as claimed in any one of the preceding claims, **characterised in that** the pressure in the filter unit (1) is 2.5-3.4 bar.

11. A system as claimed in any one of the preceding claims, **characterised in that** the grain size of the zeolite is 0.1-2.5 mm.

12. A system as claimed in any one of the preceding claims, **characterised in that** the grain size of the zeolite is 0.6-2.0 mm.

13. A system as claimed in any one of the preceding claims, **characterised in that** a bag filter (8) is placed between the filter unit (1) and the UV unit (4) to ensure a particle size of less than 1 µm also after back flushing of the filter unit (1).

14. A system as claimed in any one of the preceding claims, **characterised in that** the zeolite in the filter bed (3) is able to resist a pressure of at least 2.5 bar.

15. A method of purifying water, in particular of *Cryptosporidium*, the water being exposed to the purifying system according to claims 1-14, for producing drinking water.

16. A method of purifying water, in particular of *Cryptosporidium*, the water being exposed to the purifying system according to claims 1-14, for producing water suitable for swimming-pools.

Patentansprüche

1. System zum Reinigen von Wasser, das mindestens zwei Einheiten umfasst, von denen die erste Einheit mindestens eine Filtereinheit (1) umfasst, die besteht aus einem Behälter (2), der ein Filterbett (3) aus Zeolith enthält, und von denen die zweite Einheit (4) besteht aus einem Behälter (5), der eine UV-Lampe (6) umgibt, wobei die beiden Einheiten mittels einer Rohrleitung (7) zum Transport von Wasser miteinander verbunden sind, **dadurch gekennzeichnet, dass** das Filterbett (3) besteht aus mindestens 50 Gew.-% natürlichem Zeolith mit einem Porendurchmesser von 0,05 bis 5 nm, dass Einrichtungen vorgesehen sind, um den Druck in dem Filterbett auf 1 bis 4 bar einzustellen, und dass die UV-Lampe (6) eine Lichtstärke von 300 bis 500 J/m² hat.

2. System nach Anspruch 1, dass der natürliche Zeolith in dem Filterbett (3) vorzugsweise aus Clinoptilolith und/oder Mordenit besteht.

3. System nach Anspruch 1 oder 2, **dadurch gekenn-**

zeichnet, dass das Filterbett (3) eine innere Filteroberfläche von 50 bis 600 m²/g aufweist.

4. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Filterbett (3) eine innere Filteroberfläche von 200 bis 500 m²/g aufweist.

5. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Zeolith einen Porendurchmesser von 0,08 bis 3 nm hat.

6. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Zeolith einen Porendurchmesser von 0,1 bis 1 nm hat.

7. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Lichtstärke der UV-Lampe (6) 350 bis 450 J/m² beträgt.

8. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Lichtstärke der UV-Lampe (6) 400 bis 430 J/m² beträgt.

9. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Druck in der Filtereinheit (1) 1,5 bis 3,5 bar beträgt.

10. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Druck in der Filtereinheit (1) 2,5 bis 3,4 bar beträgt.

11. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Korngröße des Zeoliths 0,1 bis 2,5 mm beträgt.

12. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Korngröße des Zeoliths 0,6 bis 2,0 mm beträgt.

13. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** zwischen der Filtereinheit (1) und der UV-Einheit (4) ein Sackfilter (8) angeordnet ist, um eine Teilchengröße von weniger als 1 µm auch nach dem Rückspülen der Filtereinheit (1) zu gewährleisten.

14. System nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Zeolith in dem Filterbett (3) einem Druck von mindestens 2,5 bar standhalten kann.

15. Verfahren zum Reinigen von Wasser, insbesondere zur Entfernung von *Cryptosporidium*, bei dem das Wasser dem Reinigungssystem nach einem der Ansprüche 1 bis 14 ausgesetzt wird zur Herstellung von Trinkwasser.

16. Verfahren zum Reinigen von Wasser, insbesondere zur Entfernung von *Cryptosporidium*, bei dem das Wasser dem Reinigungssystem nach den Ansprüchen 1 bis 14 ausgesetzt wird zur Herstellung von Wasser, das für Swimmingpools geeignet ist.

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Revendications

1. Système de purification d'eau comprenant au moins deux unités, dont la première unité comprend au moins une unité de filtre (1) qui se compose d'une cuve (2) contenant un lit filtrant (3) de zéolite, et dont la seconde unité (4) se compose d'une cuve (5) renfermant une lampe à UV (6), lesdites deux unités étant reliées l'une à l'autre au moyen d'un conduit (7) destiné à transporter l'eau, **caractérisé en ce que** le lit filtrant (3) se compose d'au moins 50 % en poids de zéolite naturelle avec un diamètre de pores de 0,05 à 5 nm, **en ce que** des moyens sont prévus pour réguler la pression dans le lit filtrant pour qu'elle soit de 1 à 4 bars, et **en ce que** la lampe à UV (6) a une intensité lumineuse de 300 à 500 J/m². 10
2. Système selon la revendication 1, **caractérisé en ce que** la zéolite naturelle dans le lit filtrant (3) se compose de préférence de clinoptilolite et/ou de mordenite. 15
3. Système selon la revendication 1 ou 2, **caractérisé en ce que** le lit filtrant (3) a une surface filtrante intérieure de 50 à 600 m²/g. 20
4. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le lit filtrant (3) a une surface filtrante intérieure de 200 à 500 m²/g. 25
5. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la zéolite a un diamètre de pores de 0,08 à 3 nm. 30
6. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la zéolite a un diamètre de pores de 0,1 à 1 nm. 35
7. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'intensité lumineuse de la lampe à UV (6) va de 350 à 450 J/m². 40
8. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'intensité lumineuse de la lampe à UV (6) va de 400 à 430 J/m². 45
9. Système selon l'une quelconque des revendica-

tions précédentes, **caractérisé en ce que** la pression dans l'unité de filtre (1) va de 1,5 à 3,5 bars.

10. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la pression dans l'unité de filtre (1) va de 2,5 à 3,4 bars.
11. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la grosseur du grain de la zéolite va de 0,1 à 2,5 mm.
12. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la grosseur du grain de la zéolite va de 0,6 à 2,0 mm.
13. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'un** filtre à manche (8) est placé entre l'unité de filtre (1) et l'unité UV (4) pour garantir une taille de particules de moins de 1 µm également après le rinçage de l'unité de filtre (1).
14. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la zéolite dans le lit filtrant (3) est capable de résister à une pression d'au moins 2,5 bars.
15. Procédé de purification d'eau, en particulier vis-à-vis de *Cryptosporidium*, l'eau étant exposée au système de purification selon les revendications 1 à 14, pour produire de l'eau potable.
16. Procédé de purification d'eau, en particulier vis-à-vis de *Cryptosporidium*, l'eau étant exposée au système de purification selon les revendications 1 à 14, pour produire de l'eau adaptée pour les piscines.

